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FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY 'S DOCKET NUMBER: KC-0052

US APPLICATION NO (If known, see 37 CFR 1 5): 09/869580

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/GB99/04391	December 30, 1999	December 31, 1998

TITLE OF INVENTION
PLASTIC STRETCHING METHOD AND APPARATUS FOR USE IN VACUUM FORMING TECHNIQUES

APPLICANT(S) FOR DO/EO/US
Iain PRESTON and Gordon HALL

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☒ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☐ Other items or information:

U.S. APPLICATION NO (If known, see 37 CFR 1.5) 09/869580	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER

21. ☐ The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1000.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$860.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 0	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	2 - 20 =	0	x **$18.00**	$ 0
Independent claims	14 - 3 =	0	x **$80.00**	$ 0
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$270.00**	$ 0
TOTAL OF ABOVE CALCULATIONS =				$ 860.00
☒ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.			+	$ -430.00
SUBTOTAL =				$ 430.00
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$ 0
TOTAL NATIONAL FEE =				$ 0
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 0
TOTAL FEES ENCLOSED =				$ 430.00
			Amount to be refunded:	$
			charged:	$

a. ☒ A check in the amount of $ 430.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 16-0607 . A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

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SIGNATURE

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NAME

38,128
REGISTRATION NUMBER

Docket No.: KC-0052 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of :
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Iain PRESTON and Gordon HALL :
:
Serial No. New U.S. Patent Application :
:
Confirm. No.: Unassigned :
:
Filed: June 29, 2001 :
:
For: PLASTIC STRETCHING METHOD AND APPARATUS FOR USE IN VACUUM FORMING TECHNIQUES

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D. C. 20231

Sir:

Prior to initial examination of the above-identified application, please amend the application as follows:

IN THE CLAIMS:

A. Please cancel claims 1-14 without prejudice or disclaimer.

B. Please add new claims 15-28 as follows:

15. (New) A machine for stretching and vacuum forming a rectangular sheet of plastic material, the machine having a first and second orthogonal pairs of opposed elongate clamping means (1-4) which engagably co-operate with the sides of said sheet and thereby hold said sheet, wherein the elongate clamping means (1-4) comprise primary clamping means (13,14) and secondary clamping means, with the primary clamping means (13,14) engagably and fixedly clamping a side of the sheet of the plastic material and the secondary clamping means (5) engagably clamping a portion of the edge of the rectangular sheet of plastic and being adapted to move along the length of the elongate clamping means (1-4), the machine including a means to controllably urge apart a first pair of opposed elongate clamping means (1 and 3) and thereby stretch a sheet held there between characterised in that the second pair of opposed elongate clamping means (2 and 4) uses the movable secondary clamping means (5) to allow said sheet to stretch uniformly in a direction parallel to the lengths of the second pair of elongate clamping means (2 and 4) whilst resisting movement of the clamped sides of the sheet in a direction orthogonal to the lengths of the second pair of elongate clamping means (2 and 4), and once the plastic sheet has been stretched the fixed primary clamping means (13,14) are then used to hold the plastic sheet in a fixed position during the vacuum forming process.

16. (New) A machine for stretching and vacuum forming a rectangular sheet of plastic material as claimed in Claim 15, the machine including means to controllably urge apart both pairs of opposed elongate clamping means (1-4) and thereby stretch a sheet held therein in two dimensions, each elongate clamping means (1-4) using the secondary clamping means (5) to allow said sheet to stretch uniformly in a direction parallel to the length of said individual elongate clamping means (1-4) whilst resisting movement of the side of the rectangular sheet clamped by said individual elongate clamping means (1-4) in a direction orthogonal to the length of said individual elongate clamping means(1-4).

17. (New) A machine for stretching and vacuum forming a rectangular sheet of plastic material, as Claimed in Claim 15, the machine being adapted to stretch the sheet first in one direction and then subsequently in a second direction orthogonal to the first direction.

18. (New) A machine for stretching and vacuum forming a rectangular sheet of plastic as claimed in Claim 15, wherein the secondary clamps are moved along the length of the elongate clamping means by the motion of the sheet.

19. (New) A machine for stretching and vacuum forming a rectangular sheet of plastic as claimed in Claim 15, the machine having a heating means for evenly heating a plastic sheet held therein.

20. (New) A machine for stretching and vacuum forming a rectangular sheet of plastic as claimed in Claim 15, wherein the vacuum forming means is engagable and adapted to vacuum form a rectangular sheet of plastic stretched by the machine for stretching a rectangular sheet of plastic whilst said rectangular sheet of plastic is still held within the elongate clamping means (1-4) of the machine by the primary fixed clamping means (13,14).

21. (New) A machine for stretching and vacuum forming a rectangular sheet of plastic as claimed in Claim 15, the machine having a means for selectively cooling zones of the plastic sheet held therein.

22. (New) A method of stretching and vacuum forming a rectangular sheet of plastic material, the method comprising the steps of:

(a) engagably holding the sides of said sheet using movable clamping means (5); and

(b) (i) stretching said sheet along a first axis of said sheet whilst holding the sides of said sheet parallel to the first axis so as to allow the sheet to stretch proportionately along the first axis but so as to resist deformation of the sides of said sheet orthogonal to the first axis; and

(c) fixedly holding the sides of said stretched sheet using fixed clamping means; and

(d) vacuum forming said stretched sheet.

23. (New) A method of stretching and vacuum forming a rectangular sheet of plastic material as claimed in Claim 22, the method further having the step of: (b) (ii) stretching said sheet along a second axis of said sheet whilst holding the sides of said sheet parallel to the second axis so as to allow the sheet to stretch proportionately along the second axis but so as to resist deformation of the sides of said sheet orthogonal to the second axis, the second axis being orthogonal to the first axis.

24. (New) A method of stretching and vacuum forming a rectangular sheet of plastic material as claimed in Claim 22, the method involving, simultaneous to stretching said sheet parallel to a first axis, also stretching said sheet along a second axis of said sheet whilst holding the sides of said sheet parallel to the second axis so as to allow the sheet to

stretch proportionately along the second axis but so as to resist deformation of the sides of said sheet orthogonal to the second axis, the second axis being orthogonal to the first axis.

25. (New) A method of stretching and vacuum forming a rectangular sheet of plastic material as claimed in Claim 22 wherein the secondary clamps are adapted to move along the length of the elongate clamping means (1-4) proportionately to the stretching of the sheet along an axis parallel to the clamping means.

26. (New) A method of stretching and vacuum forming a rectangular sheet of plastic material as claimed in Claim 25 wherein the secondary clamps are moved along the length of the elongate clamping (1-4) means by the motion of the sheet.

27. (New) A method of stretching and vacuum forming a rectangular sheet of plastic material as claimed Claim 22, the method further having the step of heating the sheet of plastic material.

28. (New) A method of stretching and vacuum forming a rectangular sheet of plastic material as claimed in Claim 22 wherein zones of the plastic material are selectively cooled.

REMARKS

Claims 15-28 are pending. By this Amendment, claims 1-14 are cancelled and claims 15-28 are added. Prompt and favorable action on the merits is respectfully requested.

Respectfully submitted,
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PLASTIC STRETCHING METHOD AND APPARATUS FOR USE IN VACUUM FORMING TECHNIQUES

The present invention relates in general to technology for stretching plastic sheets. In particular, the invention relates to the stretching of plastic sheets as a preparation step for use with vacuum forming techniques.

Vacuum forming techniques are used in a variety of industries; for example, bathroom furnishings such as baths can be vacuum formed from a single sheet of thermoplastic material. The thermoplastic material most commonly used for vacuum forming bathroom furnishings at the present time is acrylic.

In this manufacturing process, the cost of the thermoplastic sheet represents approximately 70% of the manufacturer's final costs. It would therefore be beneficial to find a method of using less thermoplastic in the manufacturing process. However, if one simply used a thinner sheet, one would expect to produce a final product with reduced mechanical strength.

It is therefore an aim of the present invention to provide a method and apparatus for producing vacuum formed goods that uses less thermoplastic than conventional techniques whilst retaining, or even improving, mechanical strength.

We have found that a thermoplastic sheet, such as an acrylic sheet, which has been stretched before vacuum forming provides a final product which has greater mechanical strength than an unstretched sheet which has the same thickness at the start of the vacuum forming step.

However, when one considers how to implement this stretching step industrially, a technical difficulty becomes apparent. When a plastic sheet is stretched it will scallop, that is to say that it will narrow in the middle with the sides bowing inwards. This means that it will not have a constant width and thickness throughout and cannot be cut efficiently into smaller square or rectangular portions.

For example, US Patent No. 5,271,352 to Critical Sciences (Australia) Limited discloses a plastic stretching device for use in vacuum forming boat hulls. This device pulls plastic apart without any means for preventing scalloping. It is therefore impractical to use for any significant amount of stretching.

PCT/US92/07408 describes a plastic stretching device which has movable clamping means holding all sides of a plastic sheet. However, the edges of the plastic sheet would be unable to expand with the material as a whole, distorting its shape.

JP60049921 to Toyota Jidosha KK goes part of the way to solving this problem by having a plurality of clamps along at least one side of a plastic sheet. However, the movement of each clamps needs individually controlled, leading to a complex and expensive machine.

US3579718 describes an apparatus for stretching sheets of material where there are elongate clamping means which comprise a plurality of movable clamping means. However, although this allows movement of the clamps during stretching, there is no facility to then hold the stretched sheet in place to allow subsequent vacuum forming.

Similarly, US3635640 describes arrangements and methods where the apparatus of US3579718 may be used.

In JP63197626 to Shinto Kogyo KK, a plurality of clamps along opposite sides of a sheet of plastic are controlled automatically by their being mounted on endless roller chains which function to move the sheet of plastic into and out of a heating means as well as holding the plastic sheet. However, when material is stretched by this machine moving the two roller chains apart, the material edges held by the chains are unable to contract proportionately, leading to distortion of the edges and scalloping of the sheet as a whole.

The aim of this invention is therefore to provide a method of stretching plastic sheets which can be used to expand the total surface area of the sheet without distorting the sheet, wasting material or having a non-uniform thickness. In particular, the invention aims to

provide a simple controllable mechanism. Furthermore, this invention aims to stretch the plastic sheet in a manner adapted for immediate use in vacuum forming to gain the strength enhancing benefits of the stretching step.

In this application, the term "plastic" refers to any thermoplastic material.

According to a first aspect of the present invention there is provided a machine for stretching a rectangular sheet of plastic material, the machine having a first and second orthogonal pairs of opposed elongate clamping means which engagably cooperate with the sides of said sheet and thereby hold said sheet, the machine including a means to controllably urge apart a first pair of opposed elongate clamping means and thereby stretch a sheet held therebetween characterized in that the second pair of opposed elongate clamping means is adapted to allow said sheet to stretch uniformly in a direction parallel to the lengths of the second pair of elongate clamping means whilst resisting movement of the clamped sides of the sheet in a direction orthogonal to the lengths of the second pair of elongate clamping means.

Preferably, the machine includes means to controllably urge apart both pairs of opposed clamping means and thereby stretch a sheet held therein in two dimensions, each elongate clamping means being adapted to allow said sheet to stretch uniformly in a direction parallel to the length of said individual elongate clamping means whilst resisting movement of the side of the rectangular sheet clamped by said individual elongate clamping means in a

direction orthogonal to the length of said individual elongate clamping means.

The machine may be adapted to stretch the sheet first in one direction and then subsequently in a second direction orthogonal to the first direction.

Preferably, the elongate clamping means having a plurality of secondary clamps distributed along their length, the secondary clamps engagably clamping a portion of the edge of the rectangular sheet of plastic and being adapted to move along the length of the elongate clamping means proportionately to the stretching of the sheet parallel to the length of the clamping means.

More preferably, the secondary clamps are moved along the length of the elongate clamping means by the motion of the sheet.

Preferably, the clamping means have a primary clamping means which engageably and fixedly clamps a side of the sheet of the plastic material.

Preferably also, the machine has a heating means for evenly heating a plastic sheet held therein.

According to a second aspect of the present invention there is provided a machine for stretching and vacuum forming a rectangular sheet of plastic comprising a machine for stretching a rectangular sheet of plastic as claimed in any preceding Claim and an engagable vacuum forming means, wherein the engagable vacuum forming means is adapted to vacuum form a rectangular sheet of plastic stretched by the machine for stretching a rectangular

sheet of plastic whilst said rectangular sheet of plastic is still held within the elongate clamping means of the machine for stretching a rectangular sheet of plastic.

Preferably, the machine has a means for selectively cooling zones of the plastic sheet held therein.

According to a third aspect of the present invention, there is provided a method of stretching a rectangular sheet of plastic material, the method comprising the steps of:

(a) engagably holding the sides of said sheet; and
(b) stretching said sheet along a first axis of said sheet whilst holding the sides of said sheet parallel to the first axis so as to allow the sheet to stretch proportionately along the first axis but so as to resist deformation of the sides of said sheet orthogonal to the first axis.

Preferably, the method further has the step of:
(c) stretching said sheet along a second axis of said sheet whilst holding the sides of said sheet parallel to the second axis so as to allow the sheet to stretch proportionately along the second axis but so as to resist deformation of the sides of said sheet orthogonal to the second axis, the second axis being orthogonal to the first axis.

Preferably, the method involves, simultaneous to stretching said sheet parallel to a first axis, also stretching said sheet along a second axis of said sheet whilst holding the sides of said sheet parallel to the second axis so as to allow the sheet to stretch

proportionately along the second axis but so as to resist deformation of the sides of said sheet orthogonal to the second axis, the second axis being orthogonal to the first axis.

Preferably, the sides of said sheet are engageably held by a first and second orthogonal pairs of elongate clamping means which each engagably cooperate with a side of said sheet through a plurality of secondary clamps.

Preferably also, the secondary clamps are adapted to move along the length of the clamping means proportionately to the stretching of the sheet along an axis parallel to the clamping means.

Most preferably, the secondary clamps wherein the secondary clamps are moved along the length of the elongate clamping means by the motion of the sheet.

Typically, the method will have the step of heating the sheet of plastic material.

According to a fourth aspect of the present invention, there is provided a method of stretching and vacuum forming a rectangular sheet of plastic material comprising the steps of stretching a rectangular sheet of plastic according to a method as claimed in any of Claims 10 to 16 and then vacuum forming said stretched sheet of plastic.

Preferably, the edges of said sheet are engagably held by a plurality of primary clamping means before vacuum forming.

Zones of the plastic material may be selectively cooled.

An example embodiment of the present invention will now be illustrated with reference to the following figures in which:

Figure 1 is a plan view of a plastic sheet stretching machine;

Figure 2 is a cross-section through a plastic stretching machine along line AA;

Figure 3 is a perspective view of a plastic stretching machine according to the present invention;

Figure 4 is a table of results from a Notched Charpy Impact Strength test performed to BS EN ISO 179/1eA-1997; and

Figure 5 shows a plan for cutting up sheets of material in a conventional fashion and in a fashion for use with the present invention.

A plastic stretching machine shown in plan view in Figure 1 is intended for use with a rectangular sheet of plastic material or any other vacuum formable material. Elongate clamping means are provided in the form of four clamping bars (1 to 4), one to clamp each edge of the rectangular plastic sheet. Clamping bars 1 and 3 oppose each other, as do clamping bars 2 and 4. Clamping bars 1 and 2 are fixed in place, whereas clamping bars 3 and 4 may be moved, as controlled by a programmable logic controller.

Each clamping bar 1, 2, 3 and 4 comprises a plurality of secondary clamping means 5 (only some of which are labelled in Figure 1). These clamping means are mounted upon each clamp bar and may move along its length with a low co-efficient of friction.

A rectangular hot thermoplastic sheet is placed within the device and is clamped around its four edges by the secondary clamps 5. This apparatus is shown in cross-section along line AA in Figure 2. The machine may also have means to itself heat the sheet and/or keep the sheet hot.

Actuator 6 (one shown in detail as an example) activates the clamping mechanism. This causes the clamping head to be rotated around joint 7 on support assembly 8 and the plastic sheet is held in the secondary clamps 5 between plates 9 and 10. Alternate pairs of clamp bars are then pulled apart. For example, whilst clamp bar 1 is held in place, clamp bar 3 may be moved away from it, stretching the plastic sheet in the longitudinal direction. Clamp bars 2 and 4 do not move. However, the secondary clamps 5 are free to move along the clamp bars. They are pulled along by the material sheet and therefore move proportionately to the movement of clamp bar 3. They act to resist scalloping of the plastic sheet.

Similarly, clamp bar 4 can be moved away from clamp bar 2, whilst clamp bar 1 and clamp bar 3 remain in place. Again, the clamping means move proportionately to the stretching of the sheet cause by movement in clamping bar 4 and prevent scalloping. In order for this to work there has to be very low friction preventing the movement of the secondary clamping means.

Once the stretching phase has been completed, an actuator 11 acting through a thrust pin 12 engages a primary clamping means which is provided on each clamped set and comprises a top plate 13 and bottom plate 14 within which

the plastic sheet is securely held. All four sides are held at once.

A mould is then driven up through the clamped sheet forming a seal. The mould is then vacuumed by conventional means to form the resulting mould. At the end of this complete product cycle the secondary clamp carriages 5 are returned to their initial positions by the action of the primary clamp bars. A series of linkages prevent the secondary clamps 5 from getting too close to each other.

Figure 4 shows a perspective view of the combined stretching and vacuum forming machine. In this Figure, conventional vacuum forming apparatus 15 is provided underneath the stretching apparatus. The machine also provides zoned cooling for control of thickness distribution in the final product. This is a technique used in the prior art and cooling apparatus 16 is mounted above the stretching apparatus. An electronic controller 17 is provided to allow automation of the procedure.

The entire process cycle involving both the timings and movements is controlled by a computer or controlled programme logic controller. As a result of this machine it becomes possible to make considerable savings in raw material costs; for example, experiments have indicated that savings of 30% - 50% can be readily achieved. This could not be achieved simply by vacuum forming a thinner sheet of thermoplastic as only the strength benefits provided by the stretching step allow this lower volume of plastic to be used.

Figure 4 shows a table of results from a Notched Charpy Impact Strength (N.C.I.S.) test performed to BS EN ISO 179/1eA - 1997 on samples of 5mm Acrylate Capped ABS taken through the above process.

In this table, Flexural Modulus tests were performed to BS EN ISO 178 - 1997 at a test speed of 2mm/min. Sample 10 test bars were nominally 4mm thick x 10mm wide. Sample 12 test bars nominally 2.3mm thick x 15mm wide. Fallen Ball. All Notched Charpy samples that gave a valid result exhibited a partial break type.

Figure 5 (a) shows a conventional method for cutting up a sheet of plastic that is 3100mm x 1800mm to form four rectangular pieces 1750mm x 750mm for use in making a product sized 1700mm x 700mm. Note that offcuts are left around the edge. Figure 5 (b) shows how this same sheet can be cut into six rectangular pieces 1550mm x 600mm without offcuts, that may be stretched then used to give a product sized 1700mm x 700mm as before.

This reduces the time required and the space requirements for storing raw material. Additionally, fewer different sizes of sheet will have to be stocked by a manufacturer. These benefits represent a substantial cut in the cost of manufacturing the product, therefore providing an important commercial advantage.

It will be clear to one skilled in the art that this technique can be used with acrylic plastic or any other vacuum formable material. Furthermore, this plastic stretching technique will find applications in areas other than just vacuum forming.

Further modifications and improvements may be incorporated without departing from the scope of the invention herein described.

Throughout this application, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising" will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

AMENDED CLAIMS

1. A machine for stretching and vacuum forming a rectangular sheet of plastic material, the machine having a first and second orthogonal pairs of opposed elongate clamping means (1-4) which engagably co-operate with the sides of said sheet and thereby hold said sheet, wherein the elongate clamping means (1-4) comprise primary clamping means (13,14) and secondary (5) clamping means, with the primary clamping means (13,14) engagably and fixedly clamping a side of the sheet of the plastic material and the secondary clamping means (5) engagably clamping a portion of the edge of the rectangular sheet of plastic and being adapted to move along the length of the elongate clamping means (1-4), the machine including a means to controllably urge apart a first pair of opposed elongate clamping means (1 and 3) and thereby stretch a sheet held therebetween characterised in that the second pair of opposed elongate clamping means (2 and 4) uses the movable secondary clamping means (5) to allow said sheet to stretch uniformly in a direction parallel to the lengths of the second pair of elongate clamping means (2 and 4) whilst resisting movement of the clamped sides of the sheet in a direction orthogonal to the lengths of the second pair of elongate clamping means (2 and 4), and once the plastic sheet has been stretched the fixed primary clamping means (13,14) are then used to hold the plastic sheet in a fixed position during the vacuum forming process.

2. A machine for stretching and vacuum forming a rectangular sheet of plastic material as Claimed in

Claim 1, the machine including means to controllably urge apart both pairs of opposed elongate clamping means (1-4) and thereby stretch a sheet held therein in two dimensions, each elongate clamping means (1-4) using the secondary clamping means (5) to allow said sheet to stretch uniformly in a direction parallel to the length of said individual elongate clamping means (1-4) whilst resisting movement of the side of the rectangular sheet clamped by said individual elongate clamping means (1-4) in a direction orthogonal to the length of said individual elongate clamping means(1-4).

3. A machine for stretching and vacuum forming a rectangular sheet of plastic material as Claimed in Claim 1 or Claim 2, the machine being adapted to stretch the sheet first in one direction and then subsequently in a second direction orthogonal to the first direction.

4. A machine for stretching and vacuum forming a rectangular sheet of plastic as claimed in any of the previous Claims, wherein the secondary clamps are moved along the length of the elongate clamping means by the motion of the sheet.

5. A machine for stretching and vacuum forming a rectangular sheet of plastic as claimed in any preceding Claim, the machine having a heating means for evenly heating a plastic sheet held therein.

6. A machine for stretching and vacuum forming a rectangular sheet of plastic as claimed in any preceding Claim, wherein the vacuum forming means is

engagable and adapted to vacuum form a rectangular sheet of plastic stretched by the machine for stretching a rectangular sheet of plastic whilst said rectangular sheet of plastic is still held within the elongate clamping means (1-4) of the machine by the primary fixed clamping means (13,14).

7. A machine for stretching and vacuum forming a rectangular sheet of plastic as claimed in any preceding Claim, the machine having a means for selectively cooling zones of the plastic sheet held therein.

8. A method of stretching and vacuum forming a rectangular sheet of plastic material, the method comprising the steps of:
(a) engagably holding the sides of said sheet using movable clamping means (5); and
(b)(i) stretching said sheet along a first axis of said sheet whilst holding the sides of said sheet parallel to the first axis so as to allow the sheet to stretch proportionately along the first axis but so as to resist deformation of the sides of said sheet orthogonal to the first axis; and
(c) fixedly holding the sides of said stretched sheet using fixed clamping means; and
(d) vacuum forming said streched sheet.

9. A method of stretching and vacuum forming a rectangular sheet of plastic material as claimed in Claim 8, the method further having the step of:

(b)(ii) stretching said sheet along a second axis of said sheet whilst holding the sides of said sheet

parallel to the second axis so as to allow the sheet to stretch proportionately along the second axis but so as to resist deformation of the sides of said sheet orthogonal to the second axis, the second axis being orthogonal to the first axis.

10. A method of stretching and vacuum forming a rectangular sheet of plastic material as claimed in Claim 8, the method involving, simultaneous to stretching said sheet parallel to a first axis, also stretching said sheet along a second axis of said sheet whilst holding the sides of said sheet parallel to the second axis so as to allow the sheet to stretch proportionately along the second axis but so as to resist deformation of the sides of said sheet orthogonal to the second axis, the second axis being orthogonal to the first axis.

11. A method of stretching and vacuum forming a rectangular sheet of plastic material as claimed in Claim 8 wherein the secondary clamps are adapted to move along the length of the elongate clamping means (1-4) proportionately to the stretching of the sheet along an axis parallel to the clamping means.

12. A method of stretching and vacuum forming a rectangular sheet of plastic material as claimed in Claim 11 wherein the secondary clamps are moved along the length of the elongate clamping (1-4) means by the motion of the sheet.

13. A method of stretching and vacuum forming a rectangular sheet of plastic material as claimed in

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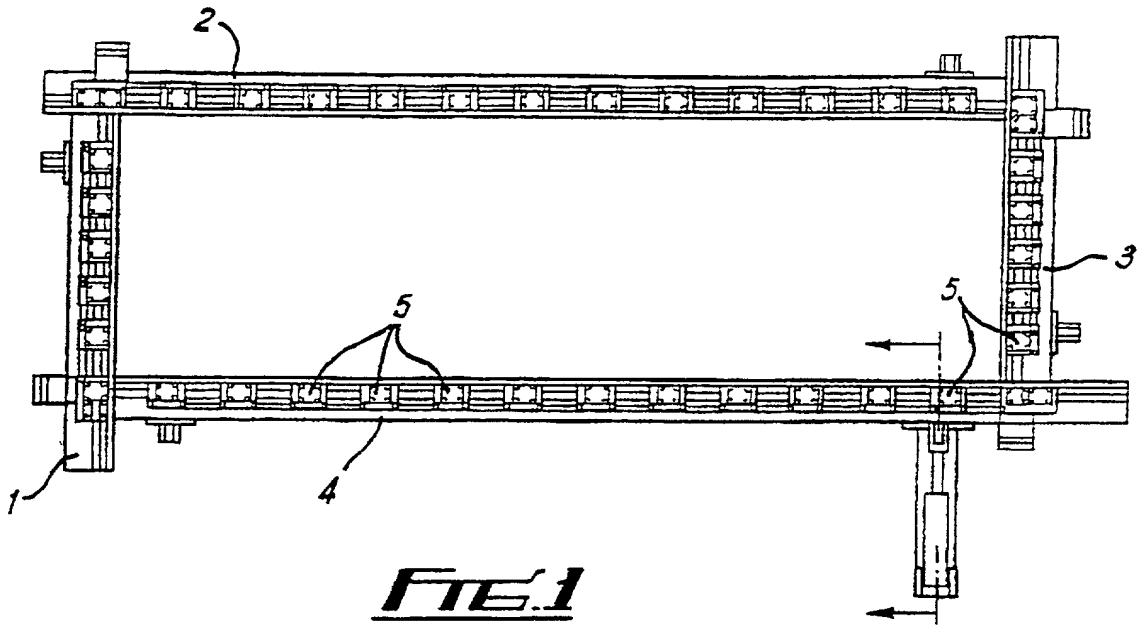

FIG.1

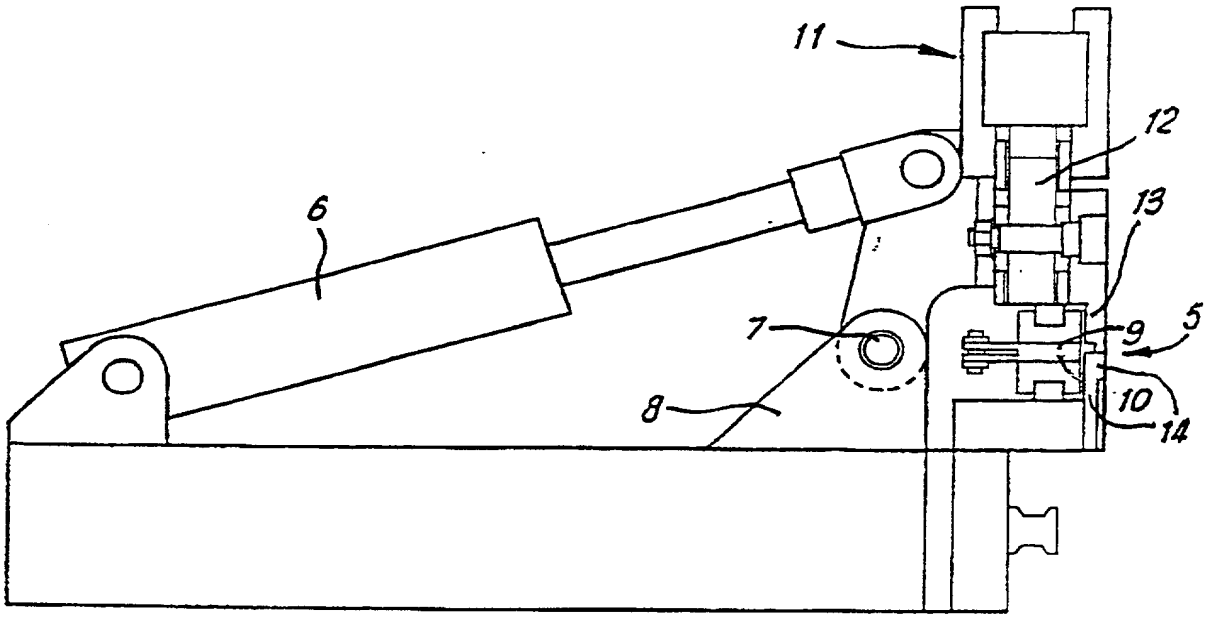

FIG 2

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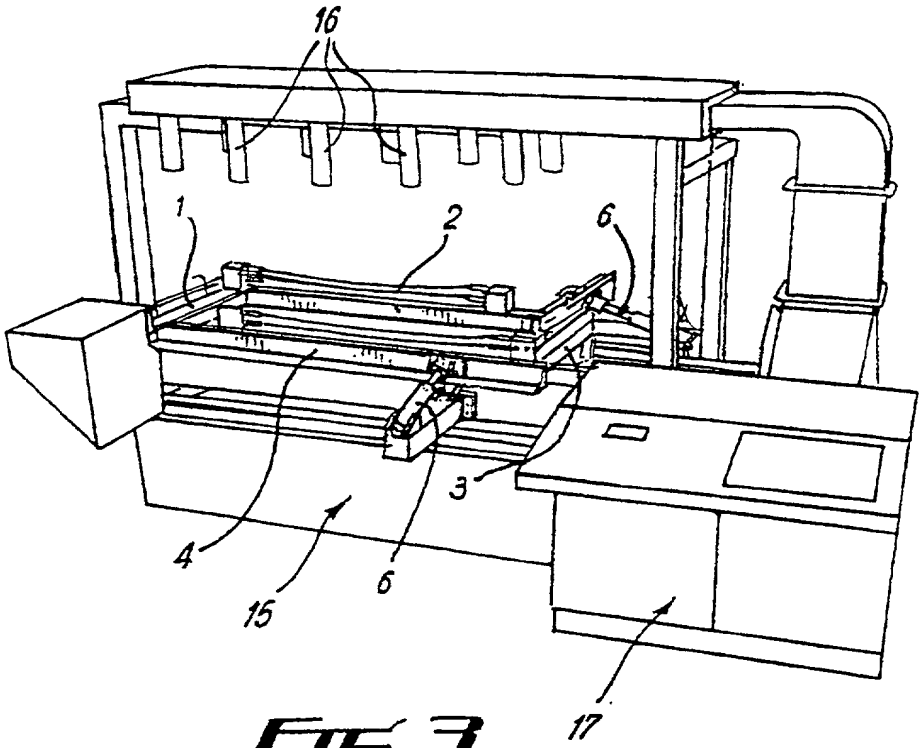

FIG. 3

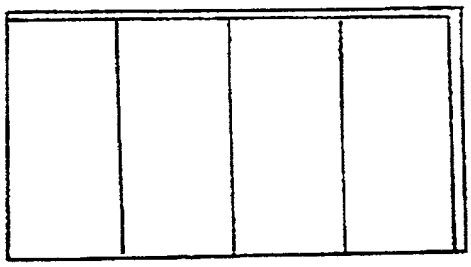

FIG. 5a

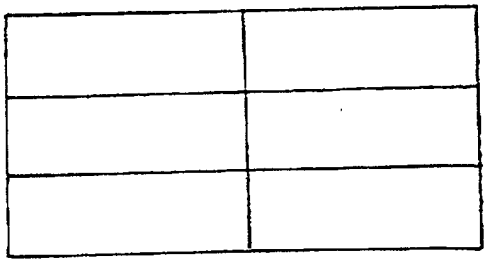

FIG. 5b

Material 10		
Sample Number	N.C.I.S @ 23°C (kJ / m^2)	Flexural Modulus (MPa)
1	87	1250
2	85	1240
3	85	1250
4	83	1280
5	88	1250
6	85	---
7	88	---
8	84	---
9	84	---
10	86	---
mean	85	1250
σ_{n-1}	1.2	7

Material 12		
Sample Number	N.C.I.S @ 23°C (kJ / m^2)	Flexural Modulus (MPa)
1	NB	1340
2	NB	1380
3	NB	1370
4	NB	1410
5	NB	1400
6	NB	---
7	83	---
8	NB	---
9	NB	---
10	NB	---
mean	N/A	1380
σ_{n-1}	N/A	28

FIG. 4

Docket No ___

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Plastic stretching method and apparatus for use in vacuum forming techniques
the specification of which

(check one) ☒ is attached hereto

☐ was filed on _____ as Application Serial No _____ and was amended on _____ (if applicable)

☐ was filed as PCT International Application No _____ and was amended under PCT Article 19 on _____

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35 United States Code 119 of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application(s) designating at least one country other than the United States of America, listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least once country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) on which priority is claimed:

Prior Foreign / PCT Application(s)

Application No	Country/PCT	Day/Month Year Filed	Priority Claimed
9828820.2	United Kingdom	31 December 1998	Yes
9925486.4	United Kingdom	28 October 1999	Yes
PCT/GB99/04391	PCT	30 December 1999	No

I hereby claim the benefit under Title 35, United States Code, 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, in so far as the subject matter of each of the claims by the first paragraph of Title 35, United States Code 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations 1.56 which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application

Prior US/PCT Applications:

(US Application Serial No)	(US Filing Date)		(Status-patented/pending/abandoned)
(US Application Serial No)	(US Filing Date)		(Status-patented/pending/abandoned)
(PCT Application No)	(US Filing Date)	(US Serial No Assigned, if any)	(Status-patented/pending/abandoned)
(PCT Application No)	(US Filing Date)	(US Serial No Assigned, if any)	(Status-patented/pending/abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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POWER OF ATTORNEY: I hereby appoint the following attorney(s) and or agent(s): Daniel Y J Kim, Registration No 36,186, and Mark L Fleshner, Registration No 34,596; Carl R Wesolowski, Registration No 40,372, and John C Eisenhart, Registration No 38,128, all of

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with full power of substitution and revocation to prosecute this applicationa nd to transact all business in the Patent and Trademark Office connection therewith, and all future correspondence should be addressed to them.

1-DD

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